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'Gala,' and the Red 'Gala' Sports: A Preliminary Comparison of Fruit Maturity

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Abstract

A comparison of fruit size, color, quality and development was made between 'Gala' apple (*malus domestica* Borkh.) and three red-colored strains of 'Gala' grown in commercial orchards in New Zealand. Differences in 'a' values of the peel suggested that red color was a poor predictor of fruit maturity, but that green-cheek 'a' values and ethylene were correlated. Preliminary comparisons suggested that 'Royal Gala' and 'Gala' apple maturation and quality were similar, although 'Regal Gala' fruit appeared to be softer, and have lower soluble solids at the same level of maturity. Measured levels of ethylene evolution ranged from 0.018 to 1.7 nl/g hr during the export-harvest period in New Zealand orchards.

Introduction

'Gala' is one of the apple cultivars growing most rapidly in worldwide popularity. In New Zealand, where 'Gala' was originally bred and propagated, uneven maturity among fruits is a major problem during harvest. Consequently, New Zealand growers will harvest each tree 4 to 6 times. As a potential remedy to this problem, a number of red-colored strains have been identified and propagated (1). In these cultivars, a greater proportion of the fruit surface develops red color early. It is not known whether this red color development is correlated to fruit maturation and quality. In addition to the question of maturity between red strains, 'Gala' maturation appears different from most early-season cultivars, due to the lack of preharvest drop and long storage potential of 'Gala' fruits.

The purpose of this study was to compare the differences in fruit physiology of three different sports of 'Gala' grown in commercial orchards. It was also undertaken to explore the maturation process of 'Gala' grown in commercial orchards. It was also undertaken to explore the maturation process of 'Gala,' and to increase our understanding of this unusual cultivar.

Materials and Methods

Fruits were harvested from commercial orchards planted in New Zealand. All plantings were located on productive orchard soils typical of the Hawkes Bay region, and were located within 5 km of one another. Since no randomized research trial was available, orchards were selected that had two strains of 'Gala' planted within 100 meters or less of each other. At Locations 1 (Raureka) and 3 (Havelock North) 'Gala' fruits were compared to fruits of a red-colored sport. In these two locations, 'Gala' trees were approximately 4 years older than the red 'Gala' trees although trees were both set on MM.106 and spaced at 3 x 4 m. These trees had attained full production. In Location 2 (Pukahu) 'Royal Gala' and 'Regal Gala' fruits were compared. At this location, trees were set at 3 x 4 m, on MM.106 roots, and in the fifth leaf. Trees were planted in parallel rows, which were about 20 m apart. Location 4 was used for testing the

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quality of 'Imperial Gala,' a second clone recently propagated. Trees at location 4 were managed similarly to the red 'Gala' trees at other sites.

Mature fruits, typical of those spot-picked for export, were harvested from ten trees of each clone at each location were harvested randomly at mid-day. Single fruit samples from each replicate tree were taken weekly on February 16, 23, and March 1, 1988. These harvest dates preceded the first three commercial pickings in each orchard. The first picking-date coincided with the release date for 'Gala' export-harvest set by the New Zealand Apple and Pear Marketing Board. At the final harvest date, trees at Locations 1, 2, and 4 had been closely-picked, leaving a light crop load for local marketing. At Location 3, maturity and harvest appeared delayed by about 1 week, as the trees were older, with large, shaded canopies. Samples harvested on each date were carefully selected to be representative of the commercial crop, both in quality and maturity.

Fruits were brought to the laboratory in Palmerston North within 3 hours of harvest, and held overnight at 22°C. Fruit maturity was assessed on the day after harvest. For ethylene determinations, individual fruits were sealed in 575 ml gas-tight canning jars fitted with a rubber septum. After 3 hours, a headspace gas sample was withdrawn, and ethylene was determined by a gas chromatograph equipped with a flame-ionization detector and an activated alumina column held at 90°C.

Table 1. Subjective assessments of fruit quality of Gala, and two red sports in the Hastings, New Zealand area.

Location	Cultivar	Red color (%)	Eating quality
February 16			
1	Gala	20 stripe	Bland, hint of varietal flavor
	Regal Gala	40 blush	Green peel flavor, no aroma
2	Regal Gala	60 blush	No varietal flavor, juicy
	Royal Gala	80 stripe	No varietal flavor, starchy
February 23			
1	Gala	30 stripe	Slight varietal flavor
	Regal Gala	80 blush	No vairetal flavor, watery
2	Regal Gala	70 blush	No varietal flavor, bland
	Royal Gala	80 stripe	Slight varietal flavor
3	Gala	30 striped	Slight varietal flavor
	Royal Gala	70 striped	No varietal flavor
March 1			
1	Gala	40 striped	Thin flavor, ripe
	Regal Gala	60 blush	Thin flavor, ripe
2	Rgal Gala	80 blush	No varietal flavor, watery
	Royal Gala	50 stripe	No varietal flavor, watery
3	Gala	40 striped	Thin flavor, ripe
	Royal Gala	50 striped	No varietal flavor, ripe

[z]Location 1 = Raureka; Location 2 = Pukahu; Location 3 = Havelock North.

Following ethylene determinations, measurements of fruit weight, length and diameter, and subjective assessments of stem end russeting, and percent red color were made. Fruit color was measured quantitatively by a Minolta Color Difference Meter (CR 100) that was standardized to a white plate provided by the manufacturer. Assessments of 'L,' 'a' and 'b' values at the equator on both the red and green cheeks were made. Fruit firmness was measured by two punctures per fruit with an Effegi penetrometer. The refractive index of the free-run juice was measured by an Atago (A-20) refractometer. Subjective assessments of flavor were also made.

Since clones of all trees were not randomized at each location, a conservative approach was taken to data analysis. T-tests were performed to test for differences between cultivar means at each location. Analyses of variance were also performed within each location to test for the effects of harvest date. Using the mean fruit weights calculated for each cultivar and harvest date, regression analyses were performed to determine the effect of harvest date on fruit weight. In this analysis, regression coefficients were used to measure the mean fruit growth rates at each location.

Results and Discussion

Subjective observations of fruit color were consistent with the expectations of these clones (Table 1). During the "export-harvest" period of this study, most fruit were found to be lacking in varietal flavor. The 'Gala' fruits sampled were slightly more-flavorful than those fruit from the red strains. This probably was due to differences in tree age, rather than an inherent differences between clones, as the 'Gala' trees at Locations 1 and 3 were the oldest trees in the study. Generally, fruit quality improves as 'Gala' trees age (D. McKenzie, personal communication).

No consistent differences in firmness, soluble solids, and ethylene evolution rates were found at locations 1 and 3, where 'Gala' was compared to a red sport (data not shown). Since 'L,' 'a' and 'b' measurements, and the appearance of the red cheek differed between the red 'Gala' fruits and 'Gala'

Table 2. A comparison of the fruit size and quality of Regal Gala and Royal Gala apple fruits harvested at location 2.

	Fruit wt (g)	Ethylene (nl/g h)	Firmness (N)	Solids (brix)
February 16				
Regal Gala	144.6	0.153	76.7	10.52
Royal Gala	139.3	0.428	90.5	11.36
T-test	NS	NS	***	NS
February 23				
Regal Gala	153.5	0.239	79.4	11.21
Royal Gala	154.4	0.280	86.6	12.72
T-test	NS	NS	*	***
March 1				
Regal Gala	166.4	0.233	78.1	11.86
Royal Gala	159.8	1.049	81.0	13.15
T-test	NS[z]	*	NS	*

[z]Nonsignificant (NS), or statistically significant at 5% (*), 1% (**), or 0.1% (***).

at these locations, it is suggested that harvesting on surface color alone is not a good predictor of maturity. Growers should be careful to judge the fruit maturity on qualitative components, rather than on blush color.

At Location 2, where plantings were closely matched in tree age and management, fruits of 'Regal Gala' and 'Royal Gala' were found to be of similar size throughout the harvest. While similar in size, 'Royal Gala' fruits had an higher level of soluble solids however. In contrast, 'Royal Gala' fruits were consistently firmer, despite higher rates of ethylene evolution (Table 2). Since these data were taken from a single orchard, they can only be regarded as preliminary. However fruit from trees in the D.S.I.R. specimen orchard in Havelock North also showed a similar pattern of differences in fruit quality between these two red sports (data not shown). At the DSIR, fruits of 'Royal Gala' and 'Regal Gala' were again similar in size, soluble solids and ethylene evolution rates, although the 'Regal Gala' fruits were significantly softer. Clearly future studies comparing fruit quality of 'Regal Gala' a blush clone, and the striped red clones are needed, as this sport is becoming quite popular.

No consistent, significant differences in measured 'L,' 'a' or 'b' values were noted across harvest dates (data not shown). It appears that the long harvest and maturity period of this cultivar, multiple spot-pickings in these orchards, and the relatively consistent weather during harvest, contributed to give similar quality fruit throughout the "export harvest" period. Since it is of interest to compare the quantitative differences in color between clones, mean values of fruit color at the equator on the red cheek are presented in Table 3. The New Zealand Apple and Pear Board produces color charts for guaging maturity. Differences in 'a' values, 'b' values, and the 'a/b' ratio suggest that separate charts for 'Gala,' 'Regal Gala' and 'Royal Gala' could be useful. No apparent difference in measured 'a' or 'b' values was noted between the two red-striped clones; 'Royal Gala' and 'Imperial Gala.'

Table 3. Seasonal surface color values measured on the red cheek of mature, spot-picked Gala, and red-Gala fruits grown at four locations in New Zealand.

	L	a	b	a/b
Location 1				
Gala	58.2[z](1.8)	16.2 (1.8)	24.6 (1.0)	0.66
Regal Gala	42.1[y](1.8)	26.8 (3.7)	17.7 (1.0)	1.54
Location 2				
Regal Gala	39.9 (0.5)	26.5 (1.9)	16.0 (0.7)	1.66
Royal Gala	43.5 (1.6)	27.7 (2.8)	19.5 90.4)	1.42
Location 3				
Gala	52.8 (0.9)	21.0 (1.7)	25.1 (0.1)	0.84
Royal Gala	42.1 (0.4)	27.0 (0.2)	18.1 (0.2)	1.49
Location 4				
Imperial Gala	43.5 (2.5)	28.4 (1.7)	18.2 (1.9)	1.56

[z]Means presented are taken from spot-picked fruit, harvested at commercial maturity on 3 dates. Ten replicate fruits were sampled from each cultivar, at each location on each date. Values in parentheses are standard errors.
[y]Increasing 'L' values denote decreasing grayness; increasing 'a' values denote increasing strength of redness; and increasing 'b' values denote increasing strength of yellowness.

Regression analyses were conducted to compare 'L,' 'a' and 'b' values with the measured rates of ethylene evolution. Measurements of 'b' values and ethylene were not significantly correlated, nor were red-cheek measurements of 'a' values and ethylene (data not shown). Significant linear correlations were noted between green-cheek 'a' values, and the measured level of ethylene evolution (Fig. 1). Assuming that ethylene evolution is a predictor of physiological maturity, 'a' values could be used to develop a series of color-standards for guaging maturity. However, these chips should be based on ground color of the green-cheek, rather than overcolor of the fruit's red-cheek.

During this study, none of the 'Gala' apple sports observed prone to preharvest drop. Measurements of ethylene evolution rates were low, in comparison to rates measured previously in early-maturing apple cultivars (4). In this study, the measured levels of ethylene evolution ranged from about 0.018 to 1.7 nl/g h. based on the calculations of apple diffusion by Solomos (3), the expected range in internal ethylene concentration would be about 0.18 to 17 ul/l. 'Gala' fruits are capable of generating far-higher internal levels once detached, (Solomos, personal communication). This suggests that the maturation of 'Gala' fruits appears to consist of a period of slowly-rising ethylene evolution on the tree, combined with a parent-plant inhibition of "authcatalytic" levels of ethylene evolution (2). This is in contrast to the behavior of 'Lodi' and 'McIntosh' studied by Walsh (4). Attached fruits of these early-season cultivars rapidly evolved "autocatalytic" concentrations of ethylene, and dropped within a few days after the onset of increased ethylene concentration.

It has been suggested that size can be a problem when growing 'Gala' apples. However, New Zealand growers have indicated that an increase in fruit growth rate can occur during maturation and harvest. While little or no significant change in fruit firmness and soluble solids were noted during the period maturation, fruit size at all locations increased significantly during this study (data not shown). Using the measured data on weekly mean fruit size, mean fruit growth rates were computed for each sampling location. Locations with the highest growth rates during maturation had higher levels of measured ethylene (Table 4). This suggests that growers who harvest early, prior to the onset of log-increased ethylene evolution, may be markedly decreasing fruit size and yield.

Table 4. Mean rates of Gala fruit growth and ethylene evolution measured during the export harvest period at four commercial orchard locations in Hasting, New Zealand in 1988.

Location	Fruit growth rate (g/week)	Ethylene evolution rate (nl/g hr) Mean	Ethylene evolution rate (nl/g hr) Range
1	7.13	0.205	0.004 to 0.700
2	10.54	0.397	0.040 to 1.717
3	10.20	0.396	0.018 to 1.028
4	2.92	0.200	0.018 to 0.476

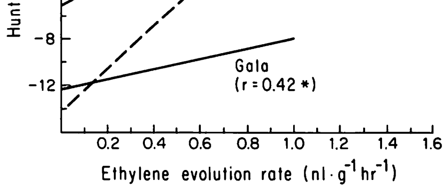

Figure 1. Relationship between ethylene evolution rate at harvest and 'a' value measured at the equator on the "green-cheek" of 'Gala,' 'Royal Gala' and 'Regal Gala' apple fruits.

In addition to problems with fruit size, growers question the quality of the newly-propagated strains of 'Gala.' Dickinson and White (1) made microscopic examinations of the epidermis and hypodermis of 25 strains of 'Gala' fruit. They found the cells of only 'Regal Gala' had small vacuoles. Fruits of all other cultivars examined had both large and small vacuoles. These data infer that anatomical and physiological differences may exist between 'Regal Gala' and other red sports. Yamaki (5) has suggested that translocated sorbitol is actively compartmentalized in the vacuole during fruit growth to creat the turgor needed for fruit growth. It is possible that the preliminary observations of vacuole size made by Dickinson and White (1), and soluble solids made here may be linked to differences in carbohydrate partitioning and fruit quality between clones.

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In Vitro Testing of the Reaction of Apple Rootstocks to *Phytophthora Cactorum*[1]

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Introduction

Crown rot caused by *Phytophthora cactorum* (Leb. & Cohn.) Schroet. is one of the most important soilborne diseases of apple, *Malus domestica* Borkh., in Washington and throughout the world. The incidence of this disease has increased with the worldwide commercial acceptance of clonal rootstocks. Since Baines (1) first demonstrated that *P. cactorum* was a causal agent of collar or crown rot on apple several other species of *Phytophthora* have also been implicated with the disease (3, 7, 8). Based on field observations plus grower complaints, MM.104 has been the most susceptible rootstock followed in order by MM.106 and M.26. The incidence of crown rot on M.7, MM.111 and seedling was similar and less than on M.26. The disease has been rare on M.9. Much of the disease on seedling is more appropriately termed collar rot in that it involves the scion rather than the rootstock.

Size-controlling clonal rootstocks are highly desirable in modern apple culture and essential for high density orchard systems (5). Experiences with the susceptible clones such as MM.104 and MM.106 point out the importance

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